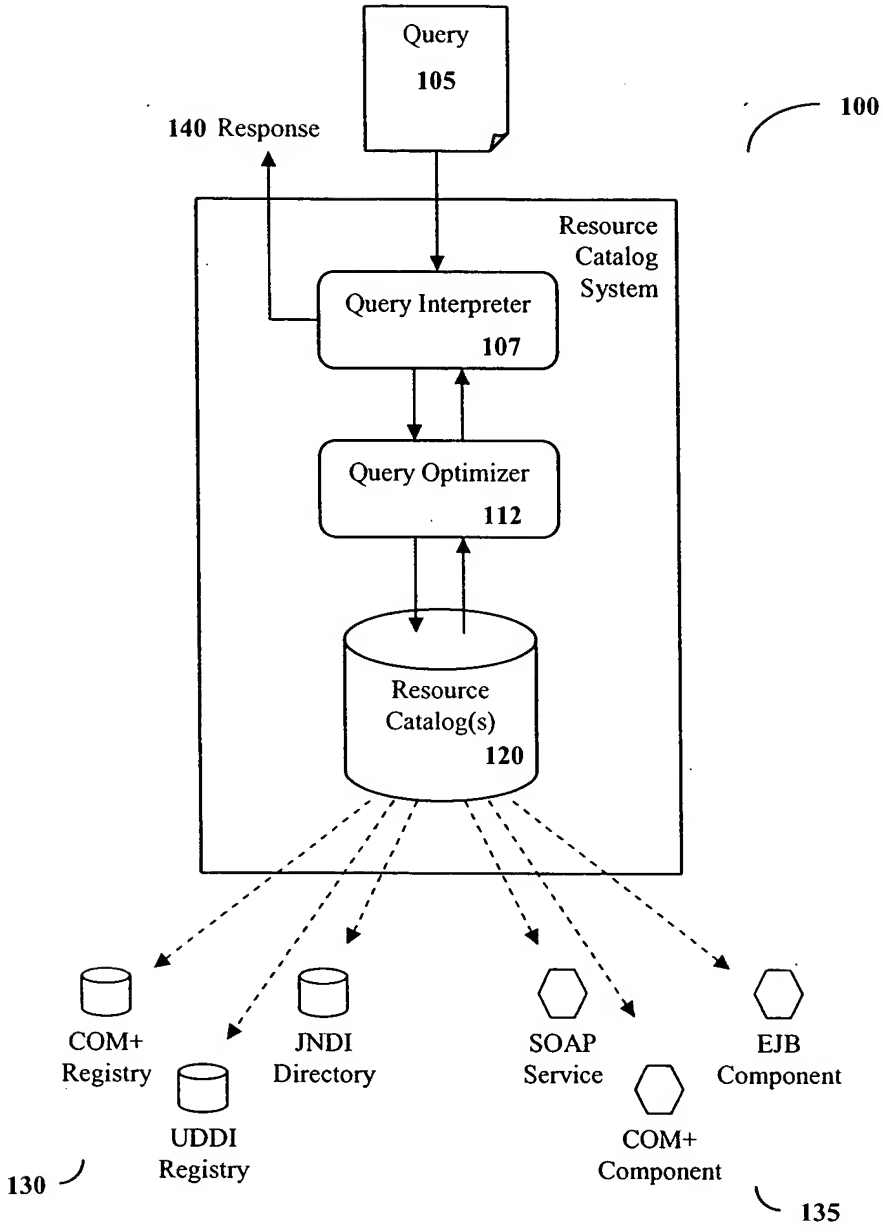
Query
105
140 Response
100
Resource
Catalog
System
Query Interpreter
107
Query Optimizer
112
Resource
Catalog(s)
120
COM+
Registry
JNDI
Directory
SOAP
Service
EJB
Component
UDDI
Registry
COM+
Component
130
135

FIG. 1

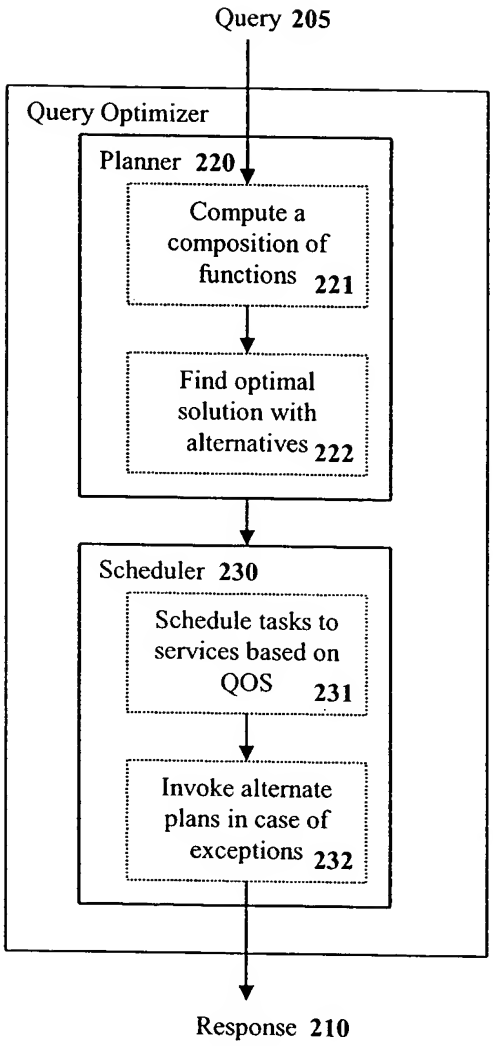
Query 205
Query Optimizer
Planner 220
Compute a composition of functions 221
Find optimal solution with alternatives 222
Scheduler 230
Schedule tasks to services based on QOS 231
Invoke alternate plans in case of exceptions 232
Response 210
200

FIG. 2

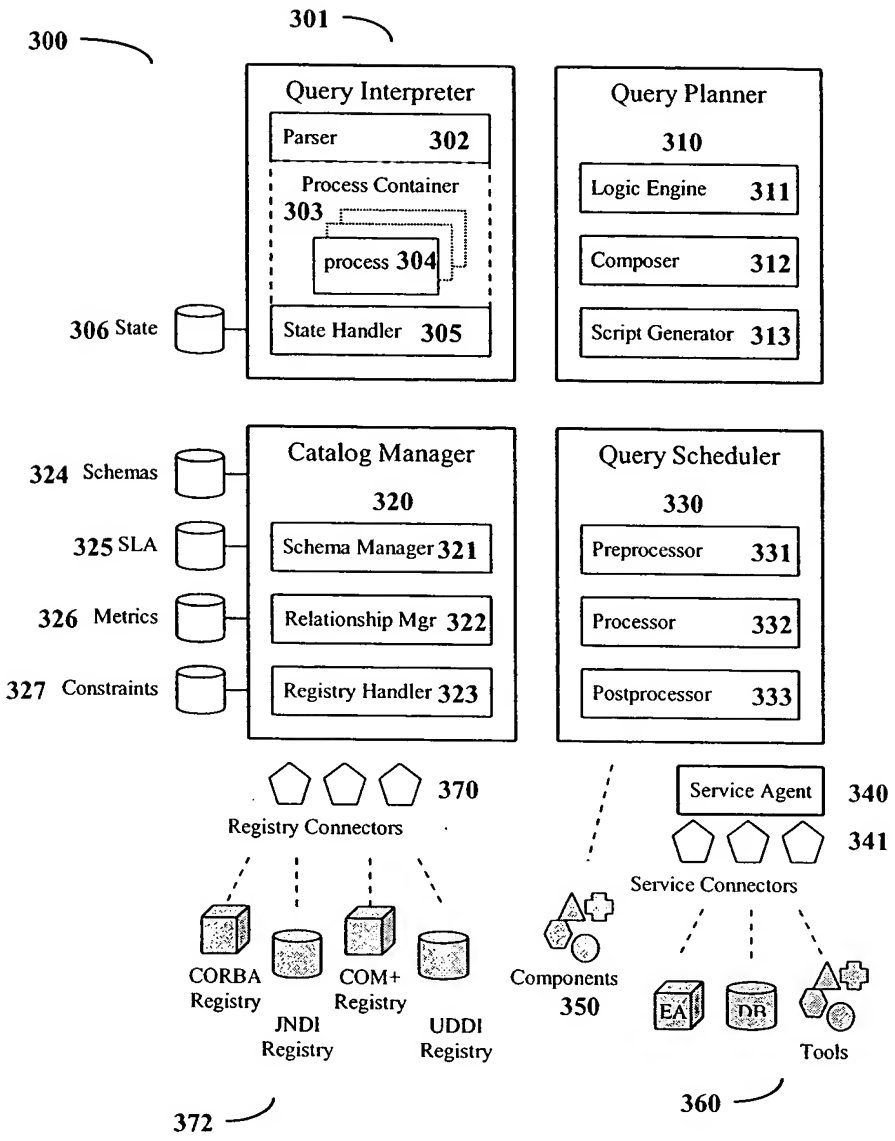
300
301
Query Interpreter
Parser 302
Process Container
303
process 304
306 State
State Handler 305
Query Planner
310
Logic Engine 311
Composer 312
Script Generator 313
324 Schemas
325 SLA
326 Metrics
327 Constraints
Catalog Manager
320
Schema Manager 321
Relationship Mgr 322
Registry Handler 323
Query Scheduler
330
Preprocessor 331
Processor 332
Postprocessor 333
370
Registry Connectors
Service Agent 340
341
Service Connectors
CORBA Registry
JNDI Registry
COM+ Registry
UDDI Registry
Components 350
EA
DB
Tools
372
360

FIG. 3

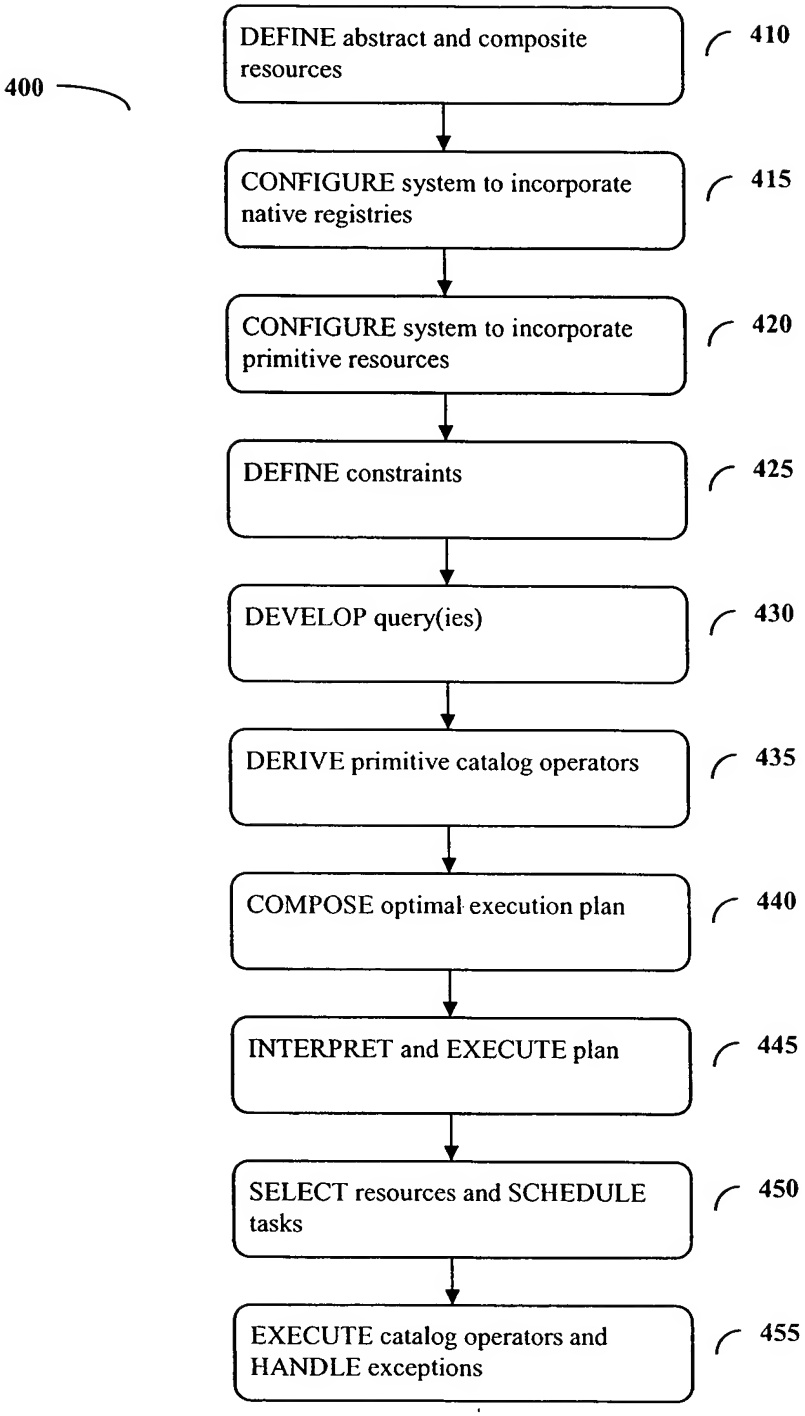
400
DEFINE abstract and composite resources
410
CONFIGURE system to incorporate native registries
415
CONFIGURE system to incorporate primitive resources
420
DEFINE constraints
425
DEVELOP query(ies)
430
DERIVE primitive catalog operators
435
COMPOSE optimal execution plan
440
INTERPRET and EXECUTE plan
445
SELECT resources and SCHEDULE tasks
450
EXECUTE catalog operators and HANDLE exceptions
455

FIG. 4

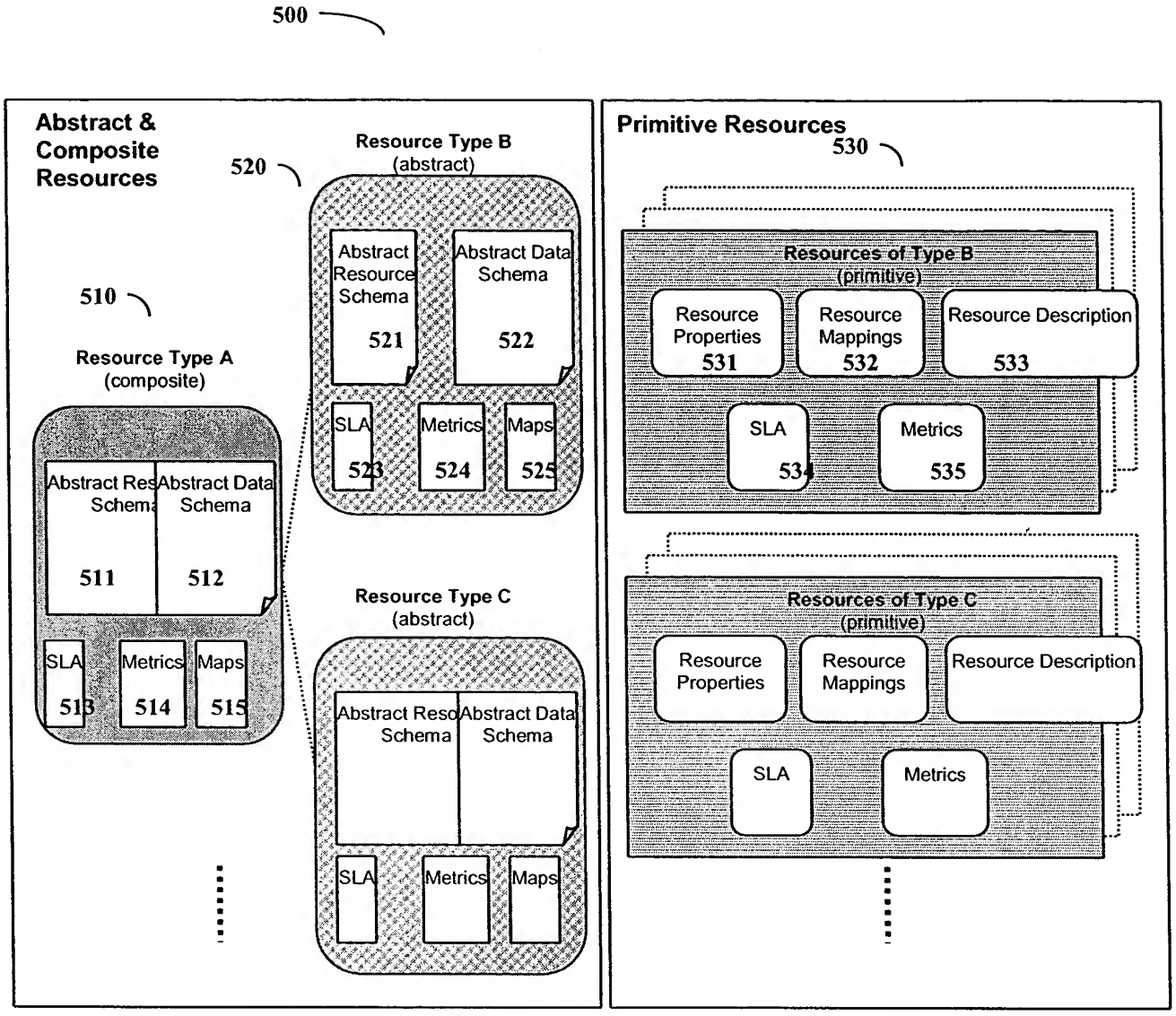
500
Abstract & Composite Resources
510
Resource Type A (composite)
Abstract Res Schema
Abstract Data Schema
511
512
SLA
513
Metrics
514
Maps
515
520
Resource Type B (abstract)
Abstract Resource Schema
521
Abstract Data Schema
522
SLA
523
Metrics
524
Maps
525
Resource Type C (abstract)
Abstract Reso Schema
Abstract Data Schema
SLA
Metrics
Maps
Primitive Resources
530
Resources of Type B (primitive)
Resource Properties
531
Resource Mappings
532
Resource Description
533
SLA
534
Metrics
535
Resources of Type C (primitive)
Resource Properties
Resource Mappings
Resource Description
SLA
Metrics

FIG. 5

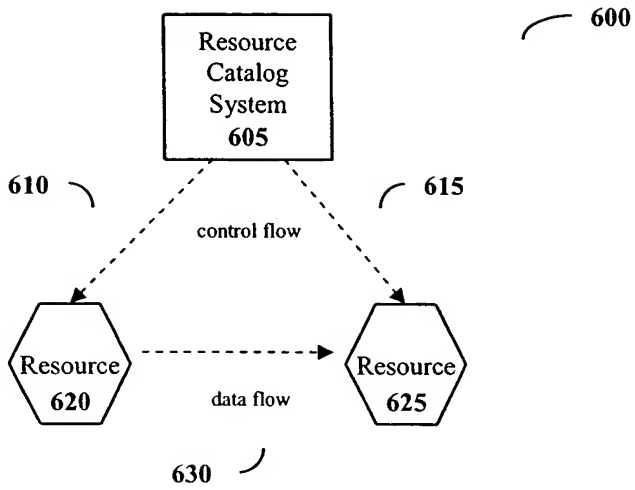
600
Resource Catalog System 605
610
615
control flow
Resource 620
data flow
Resource 625
630

FIG. 6

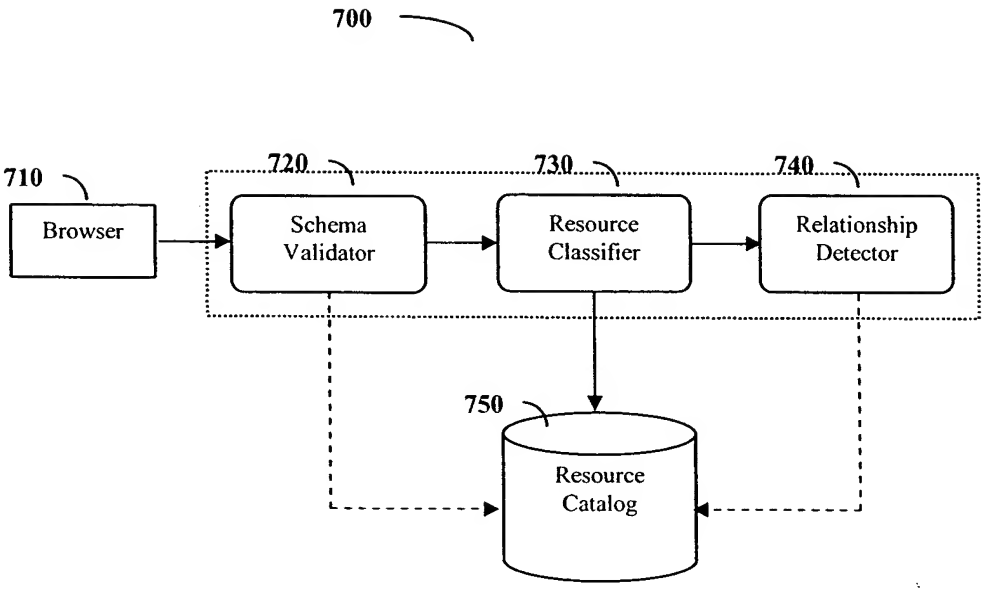
700
710
Browser
720
Schema Validator
730
Resource Classifier
740
Relationship Detector
750
Resource Catalog

FIG. 7

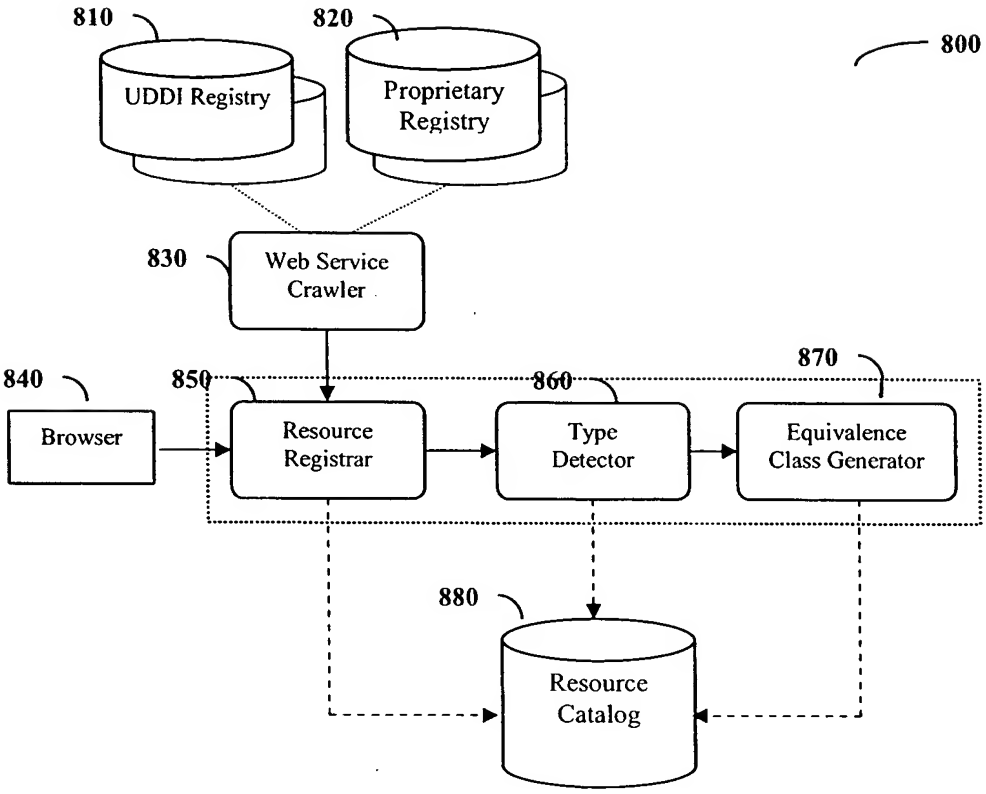
810
820
800
UDDI Registry
Proprietary Registry
830
Web Service Crawler
840
850
860
870
Browser
Resource Registrar
Type Detector
Equivalence Class Generator
880
Resource Catalog

FIG. 8

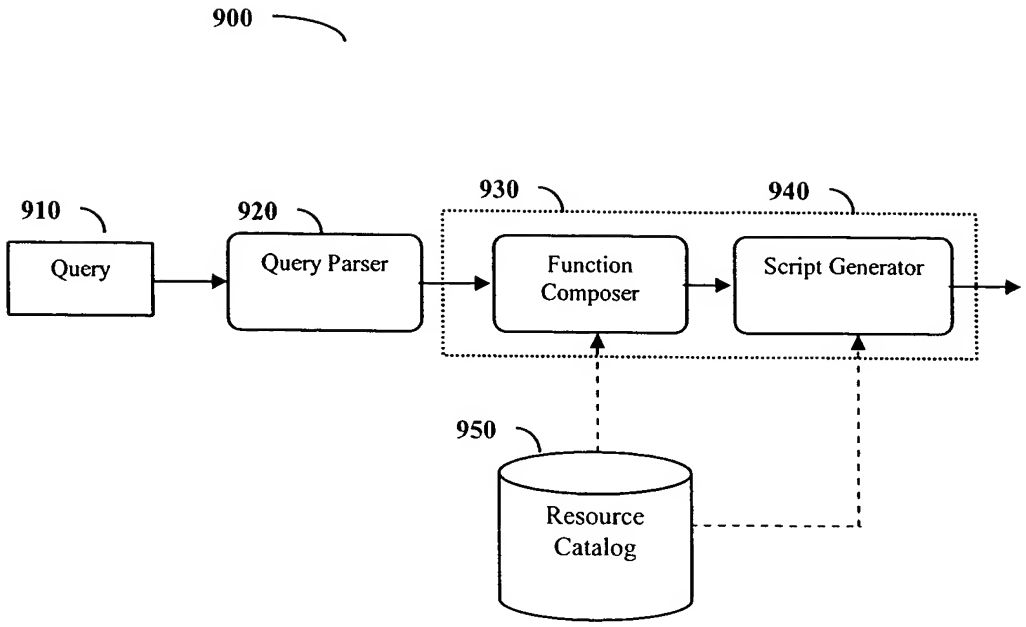
900
910
Query
920
Query Parser
930
Function Composer
940
Script Generator
950
Resource Catalog

FIG. 9

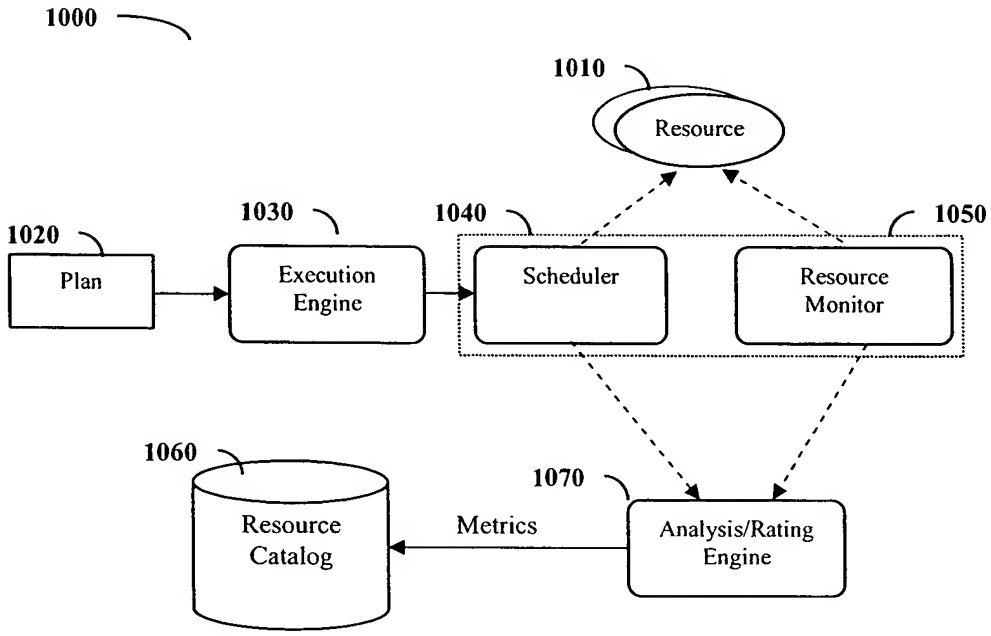
1000
1010
Resource
1020
Plan
1030
Execution Engine
1040
Scheduler
1050
Resource Monitor
1060
Resource Catalog
Metrics
1070
Analysis/Rating Engine

FIG. 10

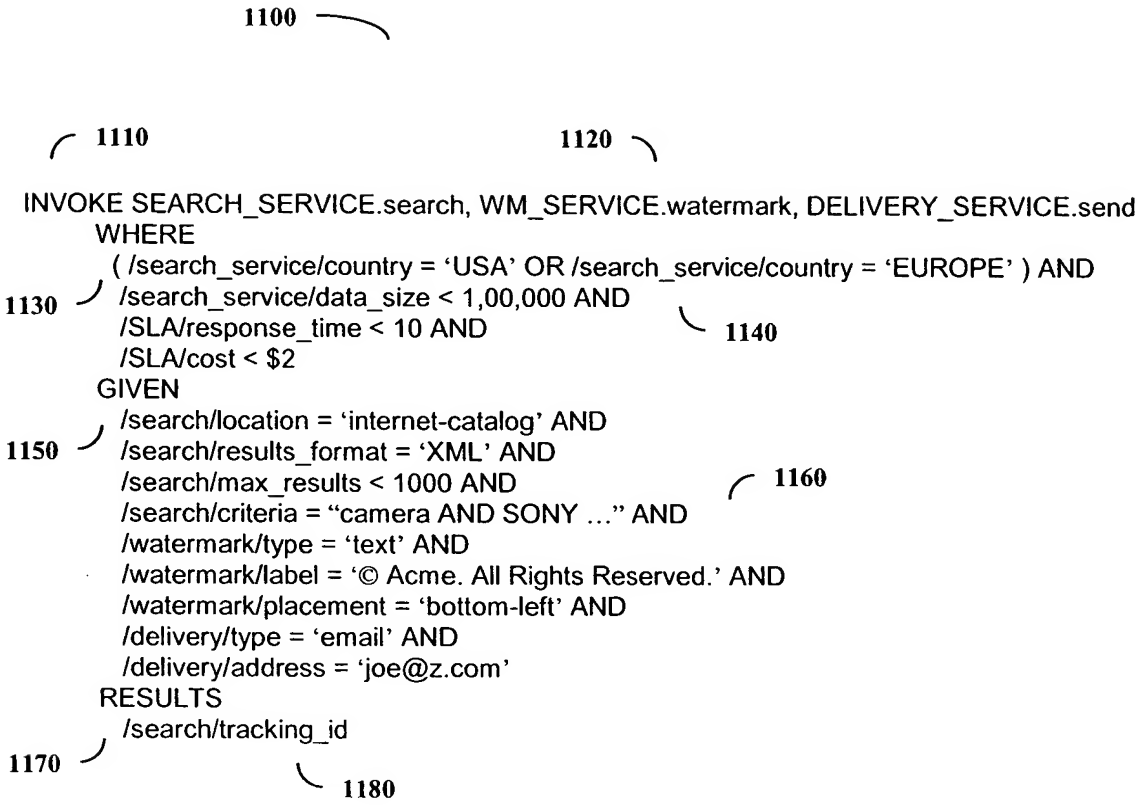
1100
1110
1120
INVOKE SEARCH_SERVICE.search, WM_SERVICE.watermark, DELIVERY_SERVICE.send
WHERE
(/search_service/country = 'USA' OR /search_service/country = 'EUROPE') AND
1130
/search_service/data_size < 1,00,000 AND
/SLA/response_time < 10 AND
1140
/SLA/cost < $2
GIVEN
/search/location = 'internet-catalog' AND
1150
/search/results_format = 'XML' AND
/search/max_results < 1000 AND
1160
/search/criteria = "camera AND SONY ..." AND
/watermark/type = 'text' AND
/watermark/label = '© Acme. All Rights Reserved.' AND
/watermark/placement = 'bottom-left' AND
/delivery/type = 'email' AND
/delivery/address = 'joe@z.com'
RESULTS
/search/tracking_id
1170
1180

FIG. 11

1200

```
<?xml version="1.0" encoding="UTF-8" ?>                    (1210, 1220)
<script major="1" minor="0" name="Example Script" access="public">

 <var name="queryResults" type="string" access="public" />
 <var name="catalogName" type="string" access="private" />   (1230)

 ...                                                        (1240)

 <task name="primary">                                      (1250)

  <assign var="catalogName" select="'Electronics Catalog'" />

  ...

  <call op="xci:acme.utility.SearchInitializer::initialize">
   <in name="catalog" select="$catalogName" />
   ...additional input parameters...
   <out name="criteria" select="$xmlCriteria" />            (1260)
   ...additional output parameters...
  </call>

  <if test="not $bCached">                                  (1270)
                                                            (1280)
  <query expression="'INVOKE MetadataExportService WHERE
      (/data/source=realestatecatalog AND /conversion/format=pdf)'"
      result="$queryResults"/>

  ...

  </if>

  <spawn tasks="taskA taskB"/>

  ...                                                       (1290)

 </task>

...

</script>
```

FIG. 12

1300

1310

```
<?xml version="1.0"?>

<component
 major="1"                    1320
 minor="0"
 package="acme.example"
 name="Workflow">

 <metadata
  version="200"                      1330
  createdBy="Acme, Inc."
  comment="Workflow provides an interface to the Workflow Manager in the Server."/>

 <operation                  1340
  name="doWork"
  access="public">                  1350

  <in name="binding" type="string"/>
  <in name="deadline" type="string"/>
  <out name="status" type="string"/>

                                                    1360
  <throws>
   <fault name="exception:InvalidParameterException"/>
   <fault name="exception:BindingException"/>
   <fault name="exception:InternalException"/>
  </throws>

  <implementation type="javaClass">
   <java classname="acme.example.WorkflowManagerInterface"
         methodname="submitWork"/>
  </implementation>                                  1370

 </operation>

</component>
```

FIG. 13

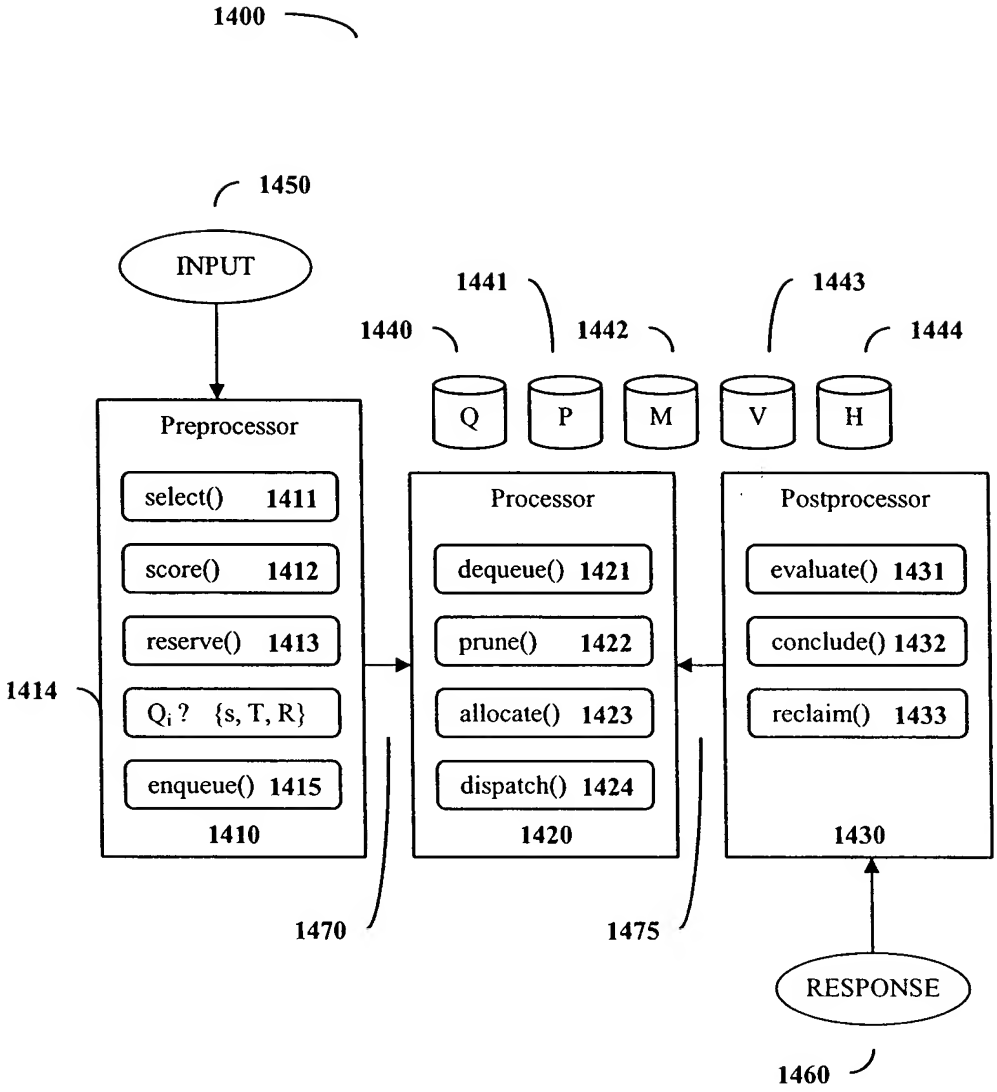
1400
1450
INPUT
1441
1443
1440
1442
1444
Q
P
M
V
H
Preprocessor
select() 1411
score() 1412
reserve() 1413
Qi ? {s, T, R}
enqueue() 1415
1410
Processor
dequeue() 1421
prune() 1422
allocate() 1423
dispatch() 1424
1420
Postprocessor
evaluate() 1431
conclude() 1432
reclaim() 1433
1430
1414
1470
1475
RESPONSE
1460

FIG. 14

Symbol	Descripti n
w_i	Worst-case time requirements for task i.
t_i	Period for task i.
d_i	Deadline for task i.
T	Set of tasks.
T_i	The i^{th} task characterized by { $[t_i,]$ $[d_i,]$ w_i }.
c	The selection criteria for a set of tasks. Represents a collection of conditions, rules or other constraints. E.g., c := { (capability = 'image conversion') AND (format = 'tiff') }.
p	The profile for the owner of the task submission. Includes preferences, service contracts, provider relationships, etc.
j	Job submission as defined by { c, p, T }
R_{all}	Set of all resources available to the systems.
R_i	The i^{th} resource.
R_{sub}	A selected subset of R_{all} that conforms to the selection criteria c.
R_{bid}	A refined subset of R_{sub} that satisfies negotiation criteria specified within p.
s	Priority score for an input set.
u	Response from a resource pertaining to completion of a task, T_i.
f	Feedback gleaned from a response u.
Q	Ready queue of input events awaiting dispatch processing.
Q_i	The i^{th} item in the ready queue defined by { s, T, $[R_{sub} \mid R_{bid}]$ }.
Q_i^k	The k^{th} task of the i^{th} item from the ready queue defined by { s, T_k }.
P	Pending queue of tasks processed by resources and awaiting results.
P_k	The kth item in the pending queue as defined by { s, T_k, R_i }
M	Mapped collection of task signatures to task results, to be described later. The collection M maintains a limited history of the actual results after processing of a task i.
V	Resource reservations list.
H	Historical information collection. Include observed performance metrics, service level agreement compliance, error rate, etc.

FIG. 14A

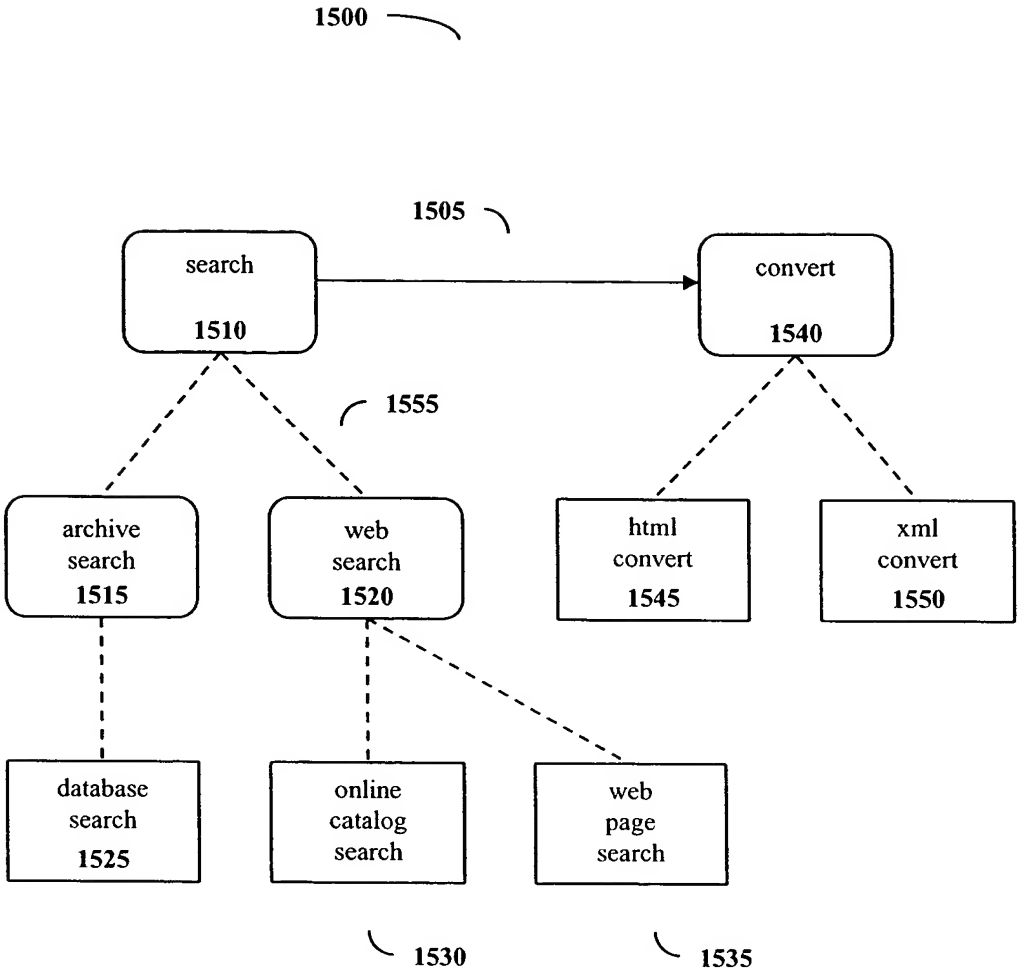
1500
1505
search
1510
convert
1540
1555
archive search
1515
web search
1520
html convert
1545
xml convert
1550
database search
1525
online catalog search
1530
web page search
1535

FIG. 15

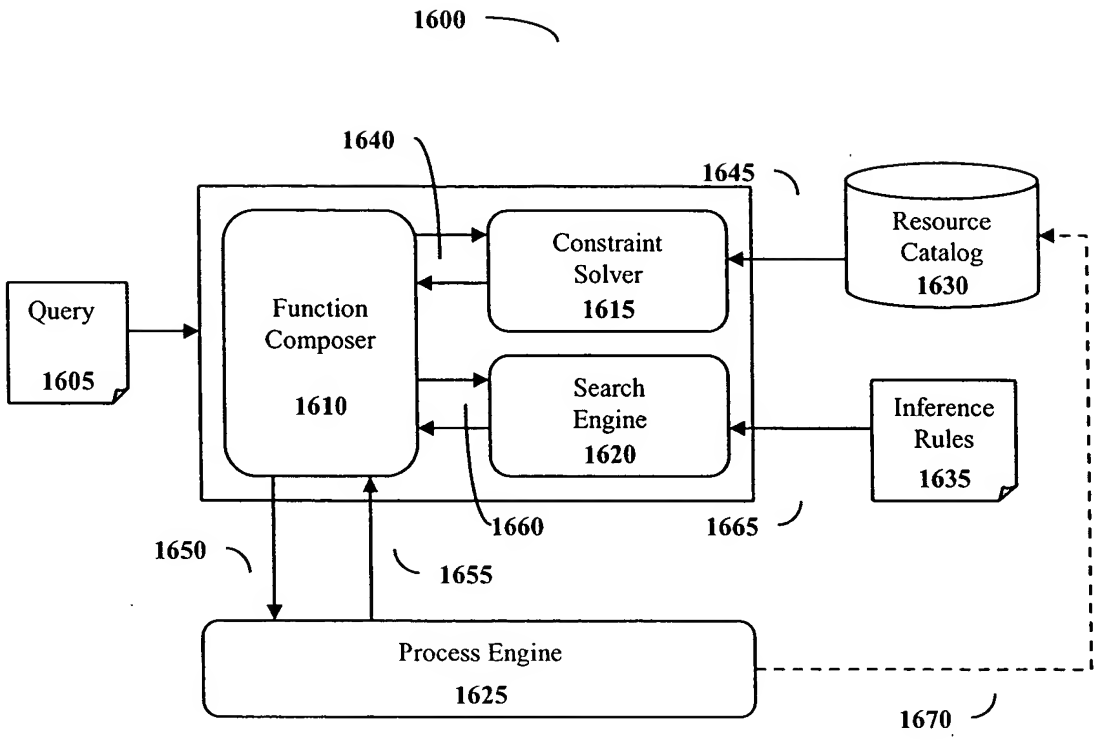
1600
1640
1645
Query
1605
Function
Composer
1610
Constraint
Solver
1615
Search
Engine
1620
Resource
Catalog
1630
Inference
Rules
1635
1650
1655
1660
1665
Process Engine
1625
1670

FIG. 16